(12) PATENT APPLICATION (11) Application No. AU 200071751 A1
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Precious metal recovery

(51)[7] International Patent Classification(s)
C22B 003/04 C22B 003/24
C22B 003/12

(21) Application No: 200071751 (22) Application Date: 2000.11.22

(30) Priority Data

(31) Number	(32) Date	(33) Country
PQ4279	1999.11.25	AU

(43) Publication Date : 2001.05.31
(43) Publication Journal Date : 2001.05.31

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ABSTRACT

The invention relates to a method of recovering a metal from a metal bearing ore wherein said method includes the steps of adding at least one ionic strength modifier to an ore bearing slurry, and subsequently conducting a metal leaching process.

AUSTRALIA
Patents Act

COMPLETE SPECIFICATION
(ORIGINAL)

Application Number:	Class	Int. Class
Lodged:		

Complete Specification Lodged:

Accepted:

Published:

Priority:

Related Art:

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Complete Specification for the invention entitled:

PRECIOUS METAL RECOVERY

Our Ref: **IRN 631257**

The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

TECHNICAL FIELD

This invention relates to the recovery of metals from their host materials. In particular it relates to the recovery of precious metals, such as gold from carbonaceous materials.

BACKGROUND ART

The invention will be preferably described in relation to the recovery of gold from carbonaceous materials. However, it should be appreciated that the invention is also useful for the recovery of other metals from such materials.

Gold which cannot be physically removed from gold bearing materials must be dissolved in order to separate it from its surrounding matrix. This process generally requires the formation of an electrically charged gold complex which is soluble under the prevailing conditions. In the gold mining industry, the dissolution of gold is commonly achieved using the CN^- ion to form a $[Au(CN)_2]^-$ complex under alkaline conditions (ie. cyanidation). Since this process requires contact between metallic gold and CN^-, the ore must first be crushed to a size which liberates most of the gold to the liquid phase. Once dissolution has been achieved, gold recovery is relatively simple. The majority of gold plants utilise carbon to adsorb $[Au(CN)_2]^-$ from the ore slurry in what is known as carbon-in-pulp (CIP) or carbon-in-leach (CIL) processing. Relatively large carbon fragments can by physically separated from a slurry and eluted (washed) to remove $[Au(CN)_2]^-$. The carbon can then be roasted to reactivate its surface. Although carbon is a very effective adsorbing agent, ore components can also bind $[Au(CN)_2]^-$ to their surface. These ore components are generally referred to in the mining industry as preg-robbers. Preg-robbers effectively compete with carbon for $[Au(CN)_2]^-$. Their competitiveness is dependent on their activity (tendency to adsorb gold) and their concentration. In general, the adsorption of gold is based on the dynamic equilibrium:

$$S+[Au(CN)_2]^-_{aqu} \leftrightarrow S[Au(CN)_2]^-_{ads}$$

The amount of adsorbed $[Au(CN)_2]^-$ on the surface of the ore is therefore proportional to the concentration of aqueous $[Au(CN)_2]^-$ ($[Au(CN)_2]^-_{aqu}$) and the availability of active surface sites (S). Therefore during CIL or CIP, $[Au(CN)_2]^-$ is in dynamic equilibrium with active sites. If the activity of S is high, then the equilibrium strongly favours the right hand side and, therefore, the adsorption of

$[Au(CN)_2]^-$. By maintaining high concentrations of carbon in the slurry, preg-robbing can be minimised. However, in some ores the prevalence and/or activity of preg-robbing species is high enough to significantly reduce leach recoveries.

In complex ore bodies, there exists a vast potential for preg-robbing agents. These range from indigenous carbonaceous materials through to inorganic species with ion exchange properties. Almost all ore types exhibit some capacity to adsorb charged species, hence the need for CIP or CIL.

Potential preg-robbing agents include oxide structures which are inherently electrostatic and carry residual surface charges. Structures such as alumina (Al_2O_3), silica (SiO_2), and a host of transition metal oxides (eg., Fe_2O_3, NiO, ZnO, MnO_2, Cr_2O_3, MoO_3, etc.) are widely used in industry as adsorbents (structures which adsorb molecules). Analogous oxide minerals which occur naturally in ore bodies in the form of clays are also well known preg-robbing agents. Naturally occurring carbonaceous material such as graphite, decaying vegetation or other organics can also act as preg-robbers by reactions alike to, and in opposition to, those of activated carbon, added for the purpose of recovering the metal. Thus for many processes relating to the recovery of metals there exists the potential for preg-robbing.

The recovery of gold may also be limited by obstruction of the pores of the adsorbent by other very fine ore particles. The effect of this is two-fold. Firstly it can physically limit the loading capacity of the adsorbent, and secondly, pore-blocking retards the rate of adsorption of dissolved gold.

In Stoychevski M. and Williams L.R., "Sodium sulfide - assisted gold recovery from arsenopyrite and roasted arsenopyrite" Transactions of the Institution of Mining and Metallurgy (Section C: Mineral Process. Extr. Metall.), Volume 102, pp C179-183, the addition of sodium sulfide during the cyanidation process was investigated. This study established that sodium sulfide addition during the cyanidation process effectively increased gold recovery by lowering the solution potential.

It was, however, noted that the effectiveness of this process was limited as that as the S^{2-} concentration was increased to sustain the solution potential at the lowest possible level, the recovery of gold was retarded possibly by the

formation of a passivating layer on the gold. In conclusion, it was found that the effectiveness of S^{2-} in enhancing gold cyanidation appeared to be limited to oxidising ore slurries at solution potentials which resulted in unfavourably high cyanide consumption.

In Australia Patent Application No. 50889/96 there is described a method of increasing the recovery of a precious metal (eg. gold) from a metal-bearing ore by adding an anti preg-robbing solvating agent (eg. a sulfur compound containing an S^- or S^{2-} functional group). The purpose of the anti preg-robbing agents being to minimise the formation of preg-robbing oxides and/or to minimise the activity of the existing preg-robbing species. This was achieved by deactivation of the active preg-robbing surface via reactions with sulfide to form passivating sulfur layers.

In other prior art methods the gold mining industry has trialed the addition of blanking agents to the ore-bearing slurry prior to conducting CIP or CIL processing. The purpose of the blanking agent being to deactivate the surface of any extraneous carbonaceous materials to minimise their ability to adsorb $[Au(CN)_2]$. In these methods a range of organic materials, whose affinity for carbon is well known, have been utilised. Of these, only kerosene and diesel have had large scale commercial success. Their application has undoubtedly been greatly assisted by their availability and cost, particularly in view of the remote location of some mining operations.

A significant limitation in the use of kerosene and diesel as well as other organic compounds in gold processing is that these compounds increase the risk of adsorbent fouling. Accordingly, any successful blanking process needs to overcome the potential of the blanking agent used (eg. kerosene or diesel) to deactivate the CIL adsorbent. Carbon fouling in CIL circuits has a compound effect which severely compromises recovery time, and is exacerbated by the added costs of regeneration.

OBJECT OF THE INVENTION

It is an object of this invention to provide conditions to increase the recovery of metals from their host materials.

It is also an object of this invention to enhance the recovery of gold by providing conditions before a traditional gold leaching process to inhibit the

adsorption of $[Au(CN)_2]$ and/or to improve the dispersion of any hydrocarbons in the ore bearing slurry.

DISCLOSURE OF THE INVENTION

Applicant has surprisingly found that precious metal recovery can be optimised by adding an ionic strength modifier to an ore bearing slurry.

Accordingly a first aspect of the invention provides, a method of recovering a metal from a metal bearing ore, wherein said method includes the following steps;

a) adding at least one ionic strength modifier to an ore bearing slurry, and subsequently

b) conducting a metal leaching process.

Applicant has also surprisingly found that precious metal recovery can be further optimised by also adding a blanking agent to the ore bearing slurry.

Thus, according to a second aspect of the invention there is provided a method of recovering a metal from a metal bearing ore, wherein said method includes the following steps:

a) adding a blanking agent to the ore bearing slurry;

b) adding at least one ionic strength modifier to an ore bearing slurry, and subsequently

c) conducting a metal leaching process.

In the second aspect of the invention, the blanking agent and the ionic strength modifier may be added to the ore bearing slurry in any order. In a preferred embodiment, the blanking agent is added to the ore bearing slurry prior to adding the ionic strength modifier. In another embodiment, the blanking agent and ionic strength modifier are added to the ore bearing slurry simultaneously. In yet another embodiment, the ionic strength modifier is added to the ore bearing slurry prior to adding the blanking agent.

Applicant, has also surprisingly found, that precious metal recovery can be further optimised by conducting an oxidation process prior to adding the ionic strength modifier.

Thus, according to a third aspect of the invention there is provided a method of recovering a metal from a metal bearing ore, wherein said method includes the following steps:

a) oxidising a metal bearing ore,

b) adding a blanking agent to the ore bearing slurry,

c) adding at least one ionic strength modifier to an ore bearing slurry, and

d) conducting a metal leaching process.

In the third aspect of the invention the metal bearing ore slurry may be initially oxidised by any suitable method. The selection of the method being dependent on the properties and constituents of the ore.

In a preferred aspect of the invention the metal bearing ore slurry may be initially oxidised by any suitable method. The selection of the method being dependent on the properties and constituents of the ore.

In a particularly preferred aspect of the invention the metal bearing ore slurry is oxidised by adding a peroxide oxidant. Examples of suitable peroxide oxidants includes solutions that contain peroxomonosulfate ions (HSO_5^-), or peroxide ions in the form of HOO^- or O_2^{2-}

In a particularly preferred embodiment of the invention the metal bearing ore slurry is initially oxidised by adding a peroxomonosulfate ion to the slurry under alkaline conditions. The peroxomonosulfate ion can be supplied in powdered form ($KHSO_5$) or in the liquid state (HSO_5^-) - also known as Caro's acid. The powder is the preferred reagent and is conveniently obtained from a triple salt with formula $KHSO_5.KHSO_4.K_2SO_4$, manufactured by Du Pont under the name of Oxone. Alternatively the peroxomonosulfate may be manufactured on site by using a chemical generator to which hydrogen peroxide (H_2O_2) and sulphuric acid (H_2SO_4) are added.

During the oxidation step, the solution potential (Eh) is preferably increased by about 100-250 mV for a minimum period of time. In practice the solution potential is initially determined by using a saturated calomel electrode (SCE) and is then increased by about 100 – 250 mV for about 15 – 45 minutes, preferably 20 – 30 minutes.

In theory the main purpose of the oxidation step is to decrease the electron density from the aromatic ring system, thus irreversibly altering the carbon surface so that it binds less intimately to $[Au(CN)_2]$ during CIL. However, in some cases excessive oxidation has proved to be detrimental. Accordingly, it is necessary to conduct a series of tests to select the optimum

oxidation potentials and residence times for each specific ore. Although, in general, applicant has noted that when Oxone is used the conditioning times should not exceed 60 minutes and the oxidant consumption should not exceed 2.0 Kg Oxone powder per ton of ore.

Ideally, the oxidation phase is controlled in a bank of small conditioning tanks. This allows for more precise control of solution potential (Eh) and retention time. Short circuiting may become a problem if only 1 tank is employed. The optimum Eh range will depend on the nature of the ore, but potentials should be set using automatic values controlled by a suitable redox probe situated in the tanks.

Owing to localised concentration effects, and the instability of peroxomonosulfate under alkaline conditions, it has been found that Oxone powder is most effective when administered as a dilute acidic solution. It should preferably not be applied in the solid form.

The oxidation pH is also ore specific and preferably an optimum range is predetermined. Generally though, peroxomonosulfate becomes increasingly unstable with increasing pH, decomposing to form molecular oxygen. Thus, it has been found the pH range is preferably maintained at below 9.0 during the oxidation step.

In the method of the invention any suitable ionic strength modifier or modifiers can be added to the metal bearing ore slurry. The selection of ionic strength modifier(s) and the amount of modifier(s) to add is dependent on the nature of the ore.

Whilst not wishing to be bound by theory, Applicant believes that, the addition of the ionic strength modifier serves three purposes. Firstly, it assists with the emulsification of the organic materials, thus minimising their contact with the adsorbent; secondly, the presence of additional cations promotes the transport of [Au $(CN)_2$] into CIL carbon; and thirdly it appears to reduce the amount of fouling of CIL carbon.

Whilst not wishing to be bound by theory, Applicant believes that the addition of a blanking agent in combination with an ionic strength modifier reduces adsorbent fouling for two reasons. Firstly, blanking agents have a greater tendency to micellise with surfactant particles present in the ore and the

resultant micelle droplets are smaller, more numerous and more stable resulting in a more stable emulsion, which limits contact of the blanking agent with the adsorbent; and secondly micellisation of ultra-fine ore particles enhances recovery by reducing physical pore-blocking of the adsorbent by such particles.

As will be appreciated any known ionic strength modifiers may be added to the metal bearing ore slurry. For example any compounds including any of the following anions may be added to the slurry OH^-, F^-, Cl^-, Br^-, I^-, CO_3^{2-}, SO_4^{2-}, CN^- and NO_3^{2-}. Compounds including, for example, any of the following cations may be added to the slurry H^+, Li^+, Na^+, K^+, Ca^{2+} and Al^{3+}.

In a preferred embodiment of the invention the ionic strength modifier(s) are selected from any one or more of the following compounds; sodium hydroxide (NaOH), sodium chloride (NaCl), calcium hydroxide ($Ca(OH)_2$), sodium cyanide (NaCN) and/or sodium carbonate (Na_2CO_3) calcium carbonate ($CaCO_3$).

In general, sodium hydroxide is preferably used as the ionic strength modifier due to its ability to promote hydrocarbon dispersion. Furthermore, it is readily available and relatively inexpensive. However, if the ore rapidly consumes OH^-, then it is preferable to cease adding sodium hydroxide and add another ionic strength modifier. For example, it may be beneficial to add sodium chloride or sodium cyanide.

The preferred ionic strength modifier can be selected by conducting a series of standard leach tests to determine the optimum precious metal recovery. In addition these standard leach tests can be used to determine the optimum modifier concentration and reaction conditions.

When sodium hydroxide is used as the ionic strength modifier then approximately 2 to 10kg of NaOH, preferably 3 to 6 kg of NaOH per tonne of ore is added to the ore bearing slurry.

In a preferred embodiment, ionic strength modifier is added to the ore bearing slurry in multiple sequential tanks whereby the electrolyte concentration in the first tank is elevated above that of the subsequent tanks. Preferably, the number of sequential tanks is between two and four.

Preferably, the ionic strength modifier is added to the ore bearing slurry using an in-line mixing system. This generates high diffusion of the ionic

strength modifier and reduces the residence time in which the pulp contacts the cyanide. This provides a greater ionic strength effect and increases emulsification.

In the method of the invention any known blanking agent may be added to the ore bearing slurry. The selection of the blanking agent and the amount of blanking agent to add will depend on the nature of the ore.

In a preferred embodiment of the invention a long chain hydrocarbon compound can be used as the blanking agent. For example any C_8 toC_{20} hydrocarbon may be used. Examples of suitable C_8 to C_{20} hydrocarbon blanking agents include octane, decane, 1-7 octadiene, dodecane, tetradecane, dodecene, chlorodecane, bromodecane, hexadecane, octadecane, eicosane or mixtures thereof. In particular either kerosene or diesel may be used as the blanking agent as they are readily available and they are relatively inexpensive. Other compounds that may be suitable as blanking agents include, for example, nitropropane, nitrobutane, hexane, petroleum ether, chlorohexane, bromohexane, xylene, octanol, decanol, 2-heptanone, dioctylether, methylnapthalene, diethylsulfide or mixtures thereof.

The preferred blanking agent can be selected by conducting a series of standard leach tests to determine the optimum precious metal recovery. In addition these standard leach tests can be used to determine the optimum reaction conditions for adding the blanking agent.

When kerosene is used as the blanking agent then it is generally added to the ore bearing slurry such that overall concentration of kerosene in the slurry is within the range of 100 to 15,000ppm, preferably within the range 250 to 10,000ppm.

In a preferred embodiment of the invention the ionic strength modifier and blanking agent may be added to the ore bearing slurry simultaneously.

Following oxidation of the ore and adding an ionic modifier and blanking agent and ionic strength modifier to the ore any suitable leaching process may be conducted.

The following examples illustrate some preferred embodiments of the invention and should not be construed as limiting the scope of this invention.

EXAMPLES

Example 1

In these examples a range of different ore samples were obtained and gold was recovered there from by traditional leaching processes. However, prior to conducting the leaching process the ore slurry was treated by the following conditioning steps;

a) addition of a blanking agent

b) addition of a blanking agent and at lease one ionic modifier, and

c) oxidising the slurry followed addition of blanking agent at least one ionic modifier.

In addition for each ore sample gold was recovered without any conditioning process. The results of these tests are provided in Table 1.

The Ores

The ores used in the tests were;

Ore A – Carbonaceous sulfide flotation concentrate

Ore B – Carbonaceous sulfide flotation tailing

Ore C – Autoclaved carbonaceous sulfide flotation concentrate

Ore D – Carbonaceous sulfide

Ore E – Carbonaceous sulfide flotation concentrate

Ore F - Bio-oxidised flotation concentrate, and

Ore G – Carbonaceous oxide.

Addition of Blanking Agent

In the examples where a blanking agent was added this was achieved by adding Kerosene and moderately agitating the slurry for 30 minutes.

Addition of Ionic Modifier

For each ore processed a different ionic modifier was added to the slurry and the selection, concentration and amount of ionic modifier are provided in table 1.

Oxidation Step

In the examples where an initial oxidation step was conducted this was achieved by adding oxone powder to the ore bearing slurry. As the optimum recovery is dependent on the solution potential (Eh) and the pH while the ore is being oxidised these values are also provided in Table 1.

Results

The results shown in Table 1 clearly indicate that when the ore slurry was conditioned either by a) addition of blanking agent and at least one ionic modifier, or by b) oxidising the slurry followed by addition of blanking agent and at least one ionic modifier that a significant increase in gold recovery was achieved.

Example 2

In this example a range of different organic compounds were tested for blanking efficiency on a highly carbonaceous sulfide. Gold was recovered from the carbonaceous sulfide using a traditional leaching process. Prior to conducting the leaching process the ore slurry was treated in individual treatments with the blanking agents listed in table 2.

A summary of the blanking efficiencies of each blanking agent is provided in table 2. The results collected from a highly carbonaceous sulfide reveals that an effective blanking agent should be:

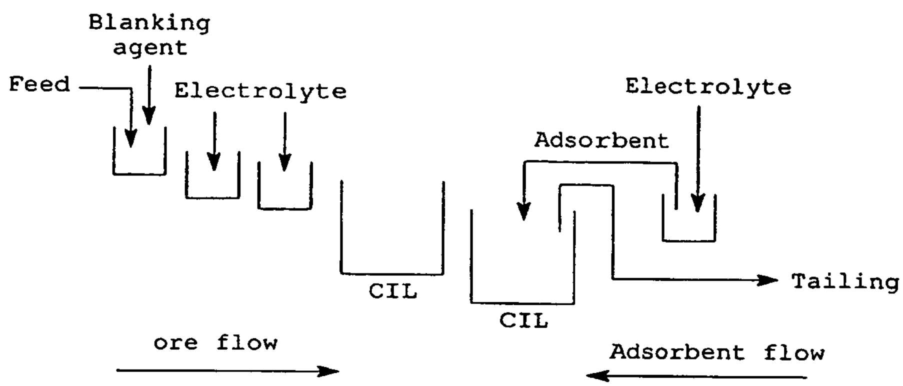
1) Immiscible with water and not subject to hydrogen bonding.
2) Limited to intermolecular (van der Waal's) bonding.
3) Lighter than water.
4) Linear in configuration.
5) Dense enough to support solid phase adhesion.

Example 3

In this example, the ability of the method of the invention to improve gold recovery from a number of different ore types was tested. Kerosene conditioning was conducted for a period of 30 minutes under moderate agitation followed by electrolyte addition for a further 30 minutes under moderate agitation. The results of treatment of a variety of commercial gold ores is shown in table 3. 'Au rec' denotes increased Au recovery in comparison to standard plant conditions. Note that ores 3 and 4 were treated by RIP using a strong base quaternary amine. It was noted that these positively charged amines were extremely resilient to hydrocarbon fouling. Primary consideration was given to cost effectiveness of the electrolyte addition.

Example 4

In this example, the process by which ionic strength adjustment is conducted on the conditioned pulp prior to CIL and on the adsorbent, is schematically represented below:



Blanking agent = kerosene, deisel, etc.
Electrolyte = NaCl, NaCN, NaOH, H_2SO_4, Na_2CO_3, etc.

This process is applicable when it is necessary to use low volumes of ionic strength modifier. For example, Applicant has found that NaCN is a highly effective ionic strength modifying electrolyte. However, its disadvantages are its toxicity, reactivity, and cost. Nevertheless, CN^- addition using the above scheme can be used to effectively facilitate emulsification prior to CIL. By dosing of CN^- in tanks of reduced size, the residence time is decreased and the instantaneous concentration of CN^- in the primary tank is increased. This scenario applies to any ionic strength modifier, but is particularly applicable to NaCN. Ideally, two to four tanks are used, thus the electrolyte concentration in the first tank is significantly elevated with respect to that which would normally be achieved in one large-volume tank. It is also possible to add kerosene, then NaCN and other ionic strength modifiers using in-line mixing systems which generate high diffusion. The shorter the residence time during initial pulp contact with cyanide, the greater the ionic strength effects and the greater the extent of emulsification. Such a regime depends on the nature of the ore involved. In the event that the pre-robbing/pore-blocking mechanisms are

extremely rapid, then leaching of gold in the absence of adsorbent may preclude an in-line system. In such cases, dosage into low volume tanks containing the adsorbent is the preferred option.

Finally, it is to be understood that various alterations, modifications and/or additions may be made to the process of the invention as previously described without departing from the spirit or ambit of the invention.

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TABLE 1

ORE	OXIDATION STEP		ADD IONIC STRENGTH MODIFIER		ADD BLANKING AGENT	ADDITIONAL GOLD RECOVERED
	Increase Eh +mV	pH	Electrolyte	Conc'n g/L	Kerosene, ppm	grams/tonne
A	N/A	N/A	N/A	N/A	N/A	0
A	N/A	N/A	N/A	N/A	250	0.9
A	N/A	N/A	NaCl NaF	5 1	250	1.75
A	200	7.5	NaCl NaF	5 1	250	2.2
B	N/A	N/A	N/A	N/A	N/A	0
B	N/A	N/A	N/A	N/A	500	0.65
B	N/A	N/A	NaCl $Na_2(CO_3)$	4 2	500	1.4
B	200	10.5	NaCl $Na_2(CO_3)$	4 2	500	1.9
C	N/A	N/A	N/A	N/A	N/A	0
C	N/A	N/A	N/A	N/A	700	1.0
C	N/A	N/A	NaCl $Na_2(CO_3)$ NaF	3 2 1	700	2.43
C	150	5.5	NaCl $Na_2(CO_3)$ NaF	3 2 1	700	3.3
D	N/A	N/A	N/A	N/A	N/A	0
D	N/A	N/A	N/A	N/A	2000	0.3
D	N/A	N/A	NaCl	6	2000	0.7
D	150	9.5	NaCl	6	2000	0.9
E	N/A	N/A	N/A	N/A	N/A	0
E	N/A	N/A	N/A	N/A	5000	2.8

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TABLE 1

ORE	OXIDATION STEP		ADD IONIC STRENGTH MODIFIER		ADD BLANKING AGENT	ADDITIONAL GOLD RECOVERED
	Increase Eh +mV	pH	Electrolyte	Conc'n g/L	Kerosene, ppm	grams/tonne
E	N/A	N/A	NaCl	10	5000	8.5
E	250	7.0	NaCl	10	5000	10.0
F	N/A	N/A	N/A	N/A	N/A	0
F	N/A	N/A	N/A	N/A	1000	0.6
F	N/A	N/A	NaCl NaF	6 2.5	1000	3.2
F	200	2.5	NaCl NaF	6 2.5	1000	4.8
G	N/A	N/A	N/A	N/A	N/A	0
G	N/A	N/A	N/A	N/A	500	0.8
G	N/A	N/A	NaCl NaF	3 1	500	3.2
G	150	8.0	NaCl NaF	3 1	500	3.5

Table 2. Blanking efficiency of various hydrocarbons on a highly carbonaceous sulfide.

Blanking agent	Description	Blanking Efficiency
C_3-C_5 halide C_3 nitro	dichloropropane,chlorobutane nitropropane	ineffective moderate
C5 alkane	pentane	ineffective
C6-C7 alkane chloride bromide	hexane, petroleum ether chlorohexane bromohexane	mild superior to hexane comparable to chlorohexane
C8-C10 alkane C8 alkene	octane, decane 1-7 octadiene	moderate comparable to C8 alkane
C12-C14 alkane C12 alkene C12 halide	dodecane, tetradecane dodecene chlorododecane bromododecane*	high comparable to C12 alkane comparable to C12 alkane inferior to C12 alkane
C16 alkane	hexadecane	slightly inferior to C12-C14
C18-20 alkane	octadecane, eicosane	problems associated with solidification
aromatic	xylene cresol* chlorobenzenes* nitrobenzene*	inferior to linear C8 ineffective ineffective ineffective
miscible alcohol	ethanol, methanol	ineffective
immiscible alcohol	octanol, decanol, cyclohexanol, phenol*	mild ineffective
ketone	2-heptanone	mild
ether	dioctylether	moderate
naptha	methylnapthalene*	mild
sulfide	diethylsulfide	mild
surfactant	sodium lauryl sulfate alkylbenzenesulfonates	ineffective ineffective
surfactant/alkane	lauryl sulfate (dilute)/dodecane lauryl sulfate (excess)/dodecane alkylsulfonate/dodecane	moderate ineffective moderate

*Denser than water

Table 3. Gold recoveries from samples obtained from gold processing plants.

Ore-type	kerosene ppm	Electrolyte	pH	Increased Au rec %
<u>Autoclave discharge</u>			<u>2.0-2.5</u>	
1. Carbonaceous	500	NaOH 2.5 g/L NaCl 1.0 g/L Na_2CO_3 0.5 g/L LiCl	>7.0	5-7
2. Non-carbonaceous	250	NaOH 2.0 g/L NaCl 1.5 g/L Na_2CO_3 0.5 g/L LiCl	>7.0	2-3
<u>Carbonaceous sulfide</u>				
3. Flotation conc.	6000	3.5 g/L NaCl 1.5 g/L NaOH 0.5 g/L NaF	9.0-9.5	15-20
4. Cyclone overflow A	2500	2.0 g/l Na_2CO_3 1.0 g/l NaCl 1.0 g/L NaOH	7.0-7.5 7.5-8.0	10-15
5. Cyclone overflow B	500	3 g/L NaCl 1.0 g/l NaOH	8.0-8.5	5-10
6. Cyclone overflow C	750	2.5 g/L NaCl 1.0 g/L NaOH 1.0 g/L Na_2CO_3	8.0-8.5	7.5-10
	0	5.0 g/L NaCl 3.0 g/L Na_2CO_3 2.0 g/L NaOH 1.0 g/L NaF		4-6

Bio-oxidised			1.5-2.0	
7. Carbonaceous	1000	NaOH 4.0 g/L NaCl 0.5 g/L NaF	>7.0	3-5
8. Non-carbonaceous A	300	NaOH 3.0 g/L NaCl	10.0	3-4
9. Non-carbonaceous B	400	NaOH 1.5 g/L NaCl 1.5 g/L Na_2CO_3	>7.0	2-3
Roasted				
10. Carbonaceous & Non-carbonaceous	500	2.5 g/L NaCl 1.0 g/L NaOH 1.0 g/L LiCl	8-9	2-4

Page(s) 14- 16 are claims pages
They appear after the table listings

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of recovering a metal from a metal bearing ore wherein said method includes the steps:

    a) adding at least one ionic strength modifier to an ore bearing slurry; and subsequently

    b) conducting a metal leaching process.

2. The method of claim 1 wherein the amount of ionic strength modifier added to the ore bearing slurry is between 2 and 10 kg per tonne of ore.

3. The method of claim 2 wherein the amount of ionic strength modifier added to the ore bearing slurry is between 3 and 6 kg per Tonne of ore.

4. The method of any one of claims 1 to 3 wherein the ionic strength modifier is selected from one or more compounds having an ion selected from OH^-, F^-, Cl^-, Br^-, I^-, $CO3^{2-}$, $SO4^{2-}$, CN^-, $NO3^{2-}$, H^+, Li^+, Na^+, K^+, Ca^{2+} or Al^{3+} or mixtures thereof.

5. The method of claim 4 wherein the ionic strength modifier is selected from one or more of sodium hydroxide, sodium chloride, calcium hydroxide, sodium carbonate, calcium carbonate, sodium cyanide or mixtures thereof.

6. The method of claim 5 wherein the ionic strength modifier is sodium hydroxide.

7. The method of claim 5 wherein the ionic strength modifier is sodium cyanide.

8. The method of any one of claims 1 to 7 wherein the ionic strength modifier is added to the ore bearing slurry in multiple sequential tanks whereby the ionic strength modifier concentration in the first tank is higher than that of subsequent tanks.

9. The method of any one of claims 1 to 8 wherein said method further includes the step of adding a blanking agent to the ore bearing slurry prior to conducting the metal leaching process.

10. The method of claim 9 wherein the ionic strength modifier is added to the metal bearing slurry prior to adding the blanking agent.

11. The method of claim 9 wherein the blanking agent is added to the metal bearing slurry prior to adding the ionic strength modifier.

12. The method of claim 9 wherein the blanking agent and ionic strength modifier are added to the metal bearing ore simultaneously.

13. The method of any one of claims 9 to 12 wherein the resulting concentration of blanking agent added to the ore bearing slurry is between 100 and 15,000 ppm.

14. The method of claim 13 wherein the resulting concentration of blanking agent is between 250 to 10,000 ppm.

15. The method of any one of claims 9 to 14 wherein the blanking agent is a linear hydrocarbon being immiscible in water, limited to intermolecular bonding, less dense than water, and having a density to support solid phase adhesion.

16. The method of claim 15 wherein the blanking agent is a hydrocarbon selected from the group comprising C_8 to C_{20} hydrocarbons, C_3 nitro, C_6-C_7 alkane, C_6-chloro, C_6 bromo, xylene, alcohol immiscible in water, ketone, ether, methylnaphthalene, diethyl sulfate or mixtures thereof.

17. The method of claim 15 wherein the blanking agent is dodecane, tetradecane or mixtures thereof.

18. The method of claim 15 wherein the blanking agent is kerosene or diesel.

19. The method of any one of claims 9 to 18 wherein said method further comprises the step of oxidising the metal bearing ore prior to adding the blanking agent and ionic strength buffer.

20. The method of claim 19 wherein the solution potential of the ore bearing slurry is increased by between 100mV to 250mV during the oxidising step.

21. The method of claim 19 or 20 wherein the pH of the ore bearing slurry is maintained below pH 9 during the oxidising step.

22. The method of any one of claims 19 to 21 wherein the oxidising step comprises adding a peroxide oxidant to the ore bearing slurry.

23. The method of claim 22 wherein the peroxide oxidant includes a peroxomonosulfate ion.

24. The method of claim 23 wherein the peroxomonosulfate ion is in a powdered form.

25. The method of claim 23 wherein the peroxide oxidant is a salt having the formula $KHSO_5$. $KHSO_4$. K_2SO_4.

26. The method of claim 23 wherein the peroxomonosulfate ion is in a liquid form.

27. A method according to claim 1 substantially as hereinbefore described with reference to any one of the examples.

DATED: 20 November 2000

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